ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

PROJECT ACRONYM: SyrNemo

PROJECT FULL TITLE: "SYNCHRONOUS RELUCTANCE NEXT GENERATION EFFICIENT MOTORS FOR ELECTRIC VEHICLES"

GRANT AGREEMENT NO: 605075

Deliverable number: D6.2

PLAN FOR THE USE AND DISSEMINATION OF FOREGROUND

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Prepared by:	Responsible lead partner (University of Bologna, Davide Fabiani and Andrea Cavallini, BOL)
Contributions by:	All partners
Approved by:	Johannes Gragger, AIT and Erwin Schlemmer, AVL (peer reviewer)

Dissemination level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission	
RE	Restricted to a group defined by the consortium (including the Commission)	
CO	Confidential, only for members of the consortium (including the Commission)	

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1 SUMMARY

This document presents the initial plan to use and disseminate the results generated by the project ("foreground") in order to promote the results as swiftly and effectively as possible to benefit the whole community and avoid duplication of R&D efforts.

Throughout the project the dissemination activities will be monitored using the *Plan for the Use and Dissemination of Foreground*. At the end of the project, a *Report on Dissemination Activities* will document the realization of the planned actions within the project and give an outlook on further use of foreground beyond the scope of the project.

2 DESCRIPTION OF DELIVERABLE

The object of this deliverable is to present an initial plan for the use and dissemination of results obtained during the project ("foreground") providing descriptions of activities and **actions to be taken in order to promote effectively the results to the whole EU automotive community**.

At the end of the project, results on the final dissemination of foreground will be described and reported as part of deliverable **D6.24 including a precise list all the dissemination activities during the 3 years of the SYRNEMO project**.

3 PLANNED DISSEMINATION ACTIVITIES

The **dissemination** of project results will **mainly be organised through WP6**. A **website** (www.syrnemo.eu) **has been created** in order to disseminate knowledge and information beyond the automotive community to make stakeholders aware of the project and towards the public as a whole. **The open part of the web site will be used to present** popularisation of **major scientific issues**. In particular, the **main events and milestones passed during the project will be highlighted** on the website, as well as the **announcement of the workshops**. The project website will allow researchers outside the Consortium to get detailed technical information on the subjects, techniques and approaches developed within the project.

The scientific project results will also be made available to the automotive community through **publications in international journals and at conferences**. This will be **encouraged by the General Assembly (GA)**. Publication rules that were established in the consortium agreement and are recalled as follows:

1. Dissemination activities including but not restricted to publications and presentations shall be governed by the procedure of Article II.30.3 of the EC-GA subject to the following provisions.
2. Prior notice of any planned publication shall be given to the other Parties concerned **at least 45 days before the publication**. **Any objection** to the planned publication **shall be made** in accordance with the GA in writing to the Coordinator and to any Party concerned **within 30 days after receipt of the notice**. **If no objection is made** within the time limit stated above, **the publication is permitted**. An objection is justified if:
    a. the objecting Party's Legitimate Interests, academic or commercial, are compromised by the publication; or
    b. the protection of the objecting Party's Foreground or Background is adversely affected.

    The objection must include a precise request for necessary modifications.
3. If an objection has been raised **the involved Parties shall discuss how to overcome the justified grounds for the objection on a timely basis** (for example by amendment to the planned publication and/or by protecting information before publication) **and the objecting Party shall not continue the opposition without valid arguments if appropriate actions are performed following the discussion**.

Dissemination activities will be performed in order to make and to disseminate the project results, generating plans for the use and dissemination of the knowledge and aiming for the support of the specifications by more than one OEM. In particular, **most of the partners will partake on presentations and international conferences displaying the efforts made in the project and showing results**. **Joint papers, standardization efforts and possible patent applications will be pursued.**

WP6 leader with the help of the other partners will identify **conferences where the project and the**

results will be presented (presentations, poster, articles, etc.) **or where special sessions can be organized** on particular topics studied to the project.

A list of some relevant conferences (not exhaustive list) is:

- IEEE Transportation and Electrification Conference and Expo (ITEC)
- IEEE International Conference on Electrical Machines and Systems (ICEMS)
- IEEE Vehicular Technology Conference (VTC)
- IEEE Vehicle Power and Propulsion Conference (VPPC)
- IEEE Symposium on Electrical Insulation (ISEI)
- IEEE Conference of Electrical Insulation and Dielectric Phenomena (CEIDP)
- International Symposium on Electrical Insulating Materials Electrical Insulation Conference (ISEIM)

In addition to these conferences, during the project duration, the progress of **SyrNemo will be presented at exhibitions and fairs regarding electromobility**. This will ensure an efficient dissemination among the European automotive community.

A dissemination workshop on electromobility will be organized during the first year of the project in Bologna by BOL and other partners (www.electromobility.ing.unibo.it). Since the development of innovative, scalable, synchronous reluctance machine (SyRM) achieving higher power density of permanent magnet machines, without or minimally using rare earth magnets is a hot topic in the field of sustainable mobility, representatives of automotive industry, OEMs, mobility managers and policy makers will be invited to participate to this workshop. In this workshop the SyrNemo concept will be presented to the public. Parties expressing their interest will be informed about the status of the project.

Another dissemination channel that will be used in SYRNEMO to achieve the expected impact of the demonstration activities is the **publication of articles in dedicated international journals and magazines**. Some of the potential international journals to publish the information can be:

1. IEEE Vehicular Technology Magazine,
2. IEEE Transactions of Industry Applications,
3. IEEE Transactions on Industrial Electronics,
4. IEEE Transactions on Power Electronics,
5. IEEE Transactions on Energy Conversion.
6. IET Electrical Systems in Transportation
7. IEEE Intelligent Transportation Systems Magazine
8. IEEE The Institute (Special edition on Electric Vehicles)

Moreover, the results will be also published in the IEEE electric vehicle website, DG Energy, DG Research and own SYRNEMO website and newsletters.

Finally, **many deliverables that have initially marked as restricted (RE) because they could contain some confidential information might be released as public based on the decision of the GA**. The final dissemination level **will be decided by the GA before the end of the project**.

4 EXPLOITATION OF THE PROJECT'S RESULTS

For effective exploitation, **proper handling of intellectual property rights is essential**.

In order to achieve this:

- **every result which might give an EU competitive advantage will be patented**. Patenting costs and maintenance fees will be shared by the partners having the main interest in the patent
- **agreements concerning the rights of protection will be made among the partners** with mutual interests
- **licensing of technology to third parties** will be considered case by case
- **use of pre-existing patents,** belonging to a project partner, by the other partners will be **secured within the Consortium Agreement**
- **the commercialisation of the results by each partner will be performed under the regulations of a contract to be negotiated in the Consortium agreement**.

The partners undertake to:

- **exploit and commercialise the results in conformity with the interests of the Community**
- **freely grant licenses and user rights among themselves to carry out the project and subsequent exploitation and commercialisation**
- **grant licenses and user rights to others needing access to the results in specified circumstances.**

The exploitation of the project results regards the knowledge of next generation electric motor for electric vehicles in terms of:

- Improved know-how in designing integrated high-performance electric motors and modeling electric and/or hybrid vehicles based on SyRMs.
- Improved know-how in designing insulation systems for high performance electric motors to improve reliability of SyRM insulation system to be used under inverter-fed voltages and typical driving cycles.
- Consolidated know-how on modeling, developing and evaluating control strategies of SyRMs.
- Pros and cons of different cooling and integration methods for electric drives in vehicles.
- Innovative control strategies for maximum efficiency operation, i.e. higher efficiency and lower costs of electric motor.
- Application of SyRM technology (first for Mini-HEV systems).
- Increase of know-how in testing and validation requirements for SYRMs (test bench and

control algorithm validation requirements).

- Development of better insights for the eco-design of electric motors that can be used in future eco-design projects.

The functioning prototype realized in the SYRNEMO project can be shown at trade fairs and elsewhere. The entire drive will be operated in a **power train in the loop test bench**. **A virtual environment will be used to demonstrate** the real world capabilities of the drive. It will be possible to perform driver in the loop activities in this virtual environment (with an immersive driving simulator), increasing the impact of the presentation activities.

In particular each partner plan to exploit it as follows:

AIT

Exploitable Results

- Improved know how in designing integrated high performance electric motors with state of the art FEA tools and in-house development of multi-domain software tools
- Innovative control strategies for maximum efficiency operation and their implementation to Cortex™ ARM® R4 digital signal processors in order to reach highest level of safety and reliability for automotive applications.
- Improved know-how in designing insulation systems
- Improved know-how on directly air cooled motors and power electronics applying the knowledge of 3D aerodynamic modeling and integrated thermal management
- Proven motor design targeting higher efficiency and lower cost of the electric motor

Exploitation objectives

- AIT plans to exploit the results aligned with its strategy research roadmap to target today´s challenges such as climate change and a depletion of raw materials by means of supporting manufactures in evaluation and design of electric drive trains. Innovative concepts and new manufacturing techniques shall be transferred to SME´s and suppliers where the increased know-how on designed electric drive trains can be applied for further research/customer projects. The Mobility Department‘s Electric Drive Technologies Business Unit will foster their position as a recognized development center for electric drive concepts and reliable partner for cooperative research projects.

AVL

Exploitable Results

- Improved know-how in modeling electric and/or hybrid vehicles featuring synchronous reluctance synchronous machines.
- Improved know-how in testing and validation requirements for SYRMs.
- Better insight into design, manufacturing, control and operation of SYRMs.
- Better understanding of aging factors of insulations systems in vehicular environments.
- Pros and cons of different cooling and integration methods for electric drives in vehicles.

Exploitation objectives

- Increased know-how for hybrid and/or electric vehicle project execution featuring the next generation of electric machines, both on research and customer level.
- The extensive test descriptions for SYRMs can be re-used for electrification projects with other types of electrical machines. Generally, the test procedures for electric machines are derived in terms of torque-speed time series from the vehicle velocity profiles of characteristic driving maneuvers (e.g. creep, launch, pure electric drive, boost, recuperation) in the System Requirement Documents. From AVL's experience, roughly two large and 5-10 small test plans (e.g. a Design Validation Plan or DVP) for hybrid power trains are generated per year in the Hybrid Development Department. In this respect, a large DVP would encompass quite extensive testing ranging from yellow-board approaches for E/E architecture over test rig installation, endurance tests and vehicle installation. The smaller DVPs have two main applications. The first one is the testing of individual components. The second objective is to provide the customer with a guideline for carrying out detailing of a fully-fledged DVP. SyrNemo has allowed AVL to generate detailed testing templates for electrical machines which comprise the most common vehicle driving scenarios, broken down to E-motor level. The physical behavior of the E-drive components can be simulated by a vehicle model that provides information about E-drive torque, speed, losses and heating as well as HV battery depletion. From the torque-speed behavior and the heating of the E-drive components, test cycles can be derived quite straightforwardly. These test cycles form the basis for individually tailored as well as generic test plans. We think that the results obtained in the SyrNemo project will allow a cost reduction in the E-drive related parts of the DVP by 10-20% which might lead to an increase of 2-3 additional small projects per year and a significant cost reduction (via re-use and refined modelling) of 2-3% for the large power train DVPs. Since large DVPs are always a part of a complete electrification project, where the DVP is only a moderate part, no estimations for additional large project acquisitions due to SyrNemo are ventured.
- During the SyrNemo project, an optimization routine for E-drive components based on Genetic Algorithms has been devised. The benefit of an optimized E-drive layout with respect to artificial and real-world driving cycle trajectories on efficiency maps is twofold: The first advantage is an optimum allocation of active volume into the available packaging space thus reducing material cost and saving room within the engine compartment. The second benefit is the location of efficiency maxima near the region on the torque-speed plane which is most densely populated by operation points from this very driving cycle. From experience it is known that a provident and sagacious choice of the efficiency map can easily save several tenth liter of fuel per 100 km. Due to the huge imponderability of penalty payments, for instance, there cannot be given any concrete value for expected savings. Nevertheless, AVL does several small Hybrid concept studies per year as basis for decision makers at OEMs. each. It is expected that with additional sales arguments, such as optimization tools, 1-2 additional projects could be acquired per year.
- For a similar reason, i.e. decision support for OEMs about Hybrid concepts, different configurations of power trains are investigated in Hybrid concept studies. The additional know-how about new and unconventional E-motor concepts – such as SYRMs - can provide a competition advantage that might lead to the acquisition of an additional concept study per year.

BOL

Exploitable Results

- Realization of a multi-stress (Thermal, Electrical and Mechanical) test chamber for accelerated life tests.
- Improved understanding of synergism between different stresses, their interactions and impact on low voltage insulation systems.
- Improved know how in designing insulation systems for high performance electric motors.

Exploitation objectives

- BOL plans to exploit the enhanced know-how acquired in the development of the project by providing the International Electrotechnical Commission (IEC) with information able to improve the current version of the 60034-18-41 standard. The know-how will also be valuable to help motor manufacturers to better qualify their insulation systems. The test chamber will be a valuable tool for further research projects.

CRF

Exploitable Results

- Improved know-how in SYRM behavior and manufacturing technology;
- Improved know-how in SYRM advanced control techniques;
- Improved know-how in SYRM for cheaper e-drive unit.

Exploitation objectives

- Validate the e-machine/power electronics integration expected technical and economic advantages to be used in EV and HEVs applications;
- Verify the expected advantages of the hairpin technology to be used in EV and HEVs applications;
- Apply SYR technology (first for Mini-HEV systems);
- Verify the expected advantages of the air cooled electric machines in parallel hybrid architecture.

HAN

Exploitable Results

- Improved know-how in designing highly utilized SYRMs
- Improved know-how in designing a modular motor that can be assembled with additional magnets
- Verification of FEM-calculations by comparing the results with FEM software of other project partners and measurements
- Improved knowledge of mechanical stress analysis on complex rotor geometries
- Development of a tool-chain to cover electromagnetic, mechanical and thermal analysis of SYRM and PMASYRM
- Increased experience with hairpin wire technology – especially on cost and manufacturing limitations

Exploitation objectives

- HAN will increase their know-how regarding the design and calculation of innovative SYRM and PMASYRM. It is planned to calculate efficiency-optimized torque-speed maps that can be used to implement innovative control strategies and thoroughly analyze the behaviour of the electric machine during dynamic driving cycles. Next to the detailed yet time-saving evaluation of the electrical machine's electromagnetic parameters, it will be able to understand the mechanical stress on the complex rotor geometry. The thorough analysis of the machine inhabits also the thermal evaluation in order to understand the overall behaviour as part of an innovative drive train. On top of that, the research on air cooled designs and the concept of using hairpin wire technology will show that the institute investigates all relevant concepts for the next generation of efficient machine concepts for electric vehicles.

TECNALIA

Exploitable Results

- Modeling and control strategies of synchronous reluctance machines, for efficiency purposes
- Design and development of testing and validation test bench of SYRMs

Exploitation objectives

- Consolidate assessment on dimensioning electric drives – based on functional powertrain requirements.
- Consolidate capacities on multi-domain modelling of eDrives (thermal, electrical), developing and evaluating control strategies of synchronous reluctance synchronous machines
- Increase know-how in testing and validation requirements for SYRMs (test bench and control algorithm validation requirements).
- The dissemination and delivery of this knowledge will increase awareness of industry needs, particularly in relation to smart synchronous reluctance machines. This enhancement will lead to new tools, techniques and improved education for students looking at a career in the Automotive industry

THIEN

Exploitable Results

1. production technologies for the active parts of the motor regarding to special electromagnetical design, which can be used in serial production
   - Up to now, TeD, together with the other project partners, learned about the production technology for hairpin windings, that tooling costs are very high and cannot be adapted for a prototype very easily. On the other hand, those toolings are capable of producing low numbers in a serial production, e.g 5000 pcs a year. The comparison between different winding technologies shows advantages for the low frequency area (up to about 150 Hz el. frequency) and enlarges the copper losses dramatically for high frequencies. Liz-wires don´t bring so much of an advantage, because the copper filling factor is reduced. For a car application regions of low speed seem to be important, all driving cycles show a focus in that region. Depending of the winding technology the height of winding heads might differ very much.
   - In case of positive tests, a cheaper insulation system might be found.
2. calculation experience and design hints for the analytical calculation of the motor from the partners, which can be used in further projects

- First, there is the usage of new materials, especially new electrical steels. The mechanical properties of improved Thyssen Krupp steel materials can be verified in the project. Furthermore there is the possibility of validation of processing influences on those materials in a real machine.
- Calculation of Iron losses: As far as known now different calculation methods will lead to different iron losses. TeD has the possibility of comparison with other calculation tools and mechanisms and improve the own calculation tool.

Exploitation objectives

• Increase of Know-How in the design of electrical machines and the SynRel in particular

After the conclusion of the SyrNemo project, THIEN eDrives can show the SyrNemo prototype to existing and future clients, demonstrating the match between design data and experimental data, and thus the high quality of the design tools.

The functioning prototype can be shown at trade fairs and elsewhere. Once a prototype has been built, further prototypes can be produced much faster since blue prints, manufacturing programs for machines and suppliers are already available. Such further prototypes can be sold to customers as validated test objects at a much lower price.

Thus, Thien eDrives expects a significant benefit for its future market position from this project. With the new technologies and knowledge about new materials, TeD might fill markets with low number serial production and high product quality. Numbers might be between 5000 and 15.000 from 2018/2019 on.

VUB

Exploitable Results

- Development of new databases, and enhancement of available databases, for environmental LCA, life cycle costing, and social LCA of electric motors
- Better understanding of social life cycle issues associated to the production of electric motors
- Development of sustainability methodology based on life cycle thinking with focus on the electromobility sector
- Experience on the estimation of environmental, social and economic impacts with the use of state of the art LCA software and specialized databases

Exploitation objectives

- Development of better insights for the eco-design of electric motors, and energy intensive machines, that can be used in future eco-design projects.
- The development of methodologies, know-how and experience on sustainability assessment for e-motors can be extended to broader fields in the electric vehicles and energy sectors for future projects and research
- Consolidated expertise in the field of environmental assessments for EV and verified expected impacts generated by technology used in EV applications, opening opportunities for governmental policy advising, contributions to design of technology at industrial level, and other research projects

5 MANAGEMENT OF INTELLECTUAL PROPERTY

Detailed rules on the management of the intellectual property have been agreed among partners and are detailed in the consortium agreement.